Table of Contents

Fundamentals of ABS

Initial Print Date:1/03 Revision Date:

Model: Fundamentals of Anti-Lock Brakes

Production: All with ABS

Objectives:

After completion of this module you will be able to:

- Understand Basic ABS operation

Purpose of System

Anti-Lock Brake System Theory

The ability to slow or stop a vehicle depends upon the braking forces applied to the wheels and the frictional contact that exists between the tires and the road surface. Very low frictional forces exist when the tire is locked (or skidding). A locked tire also causes a loss or the lateral locating forces that effect directional control of the vehicle. The result of a locked tire (or tires) is the loss of steering control and stability. The major forces that affect how easy a tire will lock include:

- The braking force applied from the vehicles braking system.
- Environmental factors - rain - ice - snow - etc.
- Type and condition of the road surface.
- Condition of the tires (tread and design).

The anti-lock braking system is designed to allow the maximum amount of braking force to be applied to the wheels without allowing the wheels to lock or skid. The advantages that ABS provides includes:

- Driving stability - by maintaining the lateral locating forces between the tires and the road surface
- Steerability - allowing the driver to continue to steer the vehicle while stopping (even during panic stops) or accident avoidance maneuvers.
- Provides optimum braking distances - the rolling wheels transfer higher frictional forces to slow the vehicle.

Brake Regulation

In order to prevent the wheels from locking during braking, yet provide the optimum braking force for maximum braking efficiency, the ABS braking system must:

- Have the ability to monitor the wheel rotation rates
- Be able to regulate the braking forces applied to the wheels.

The ABS system carries out these functions with an electronic control system. The components of the ABS system include:

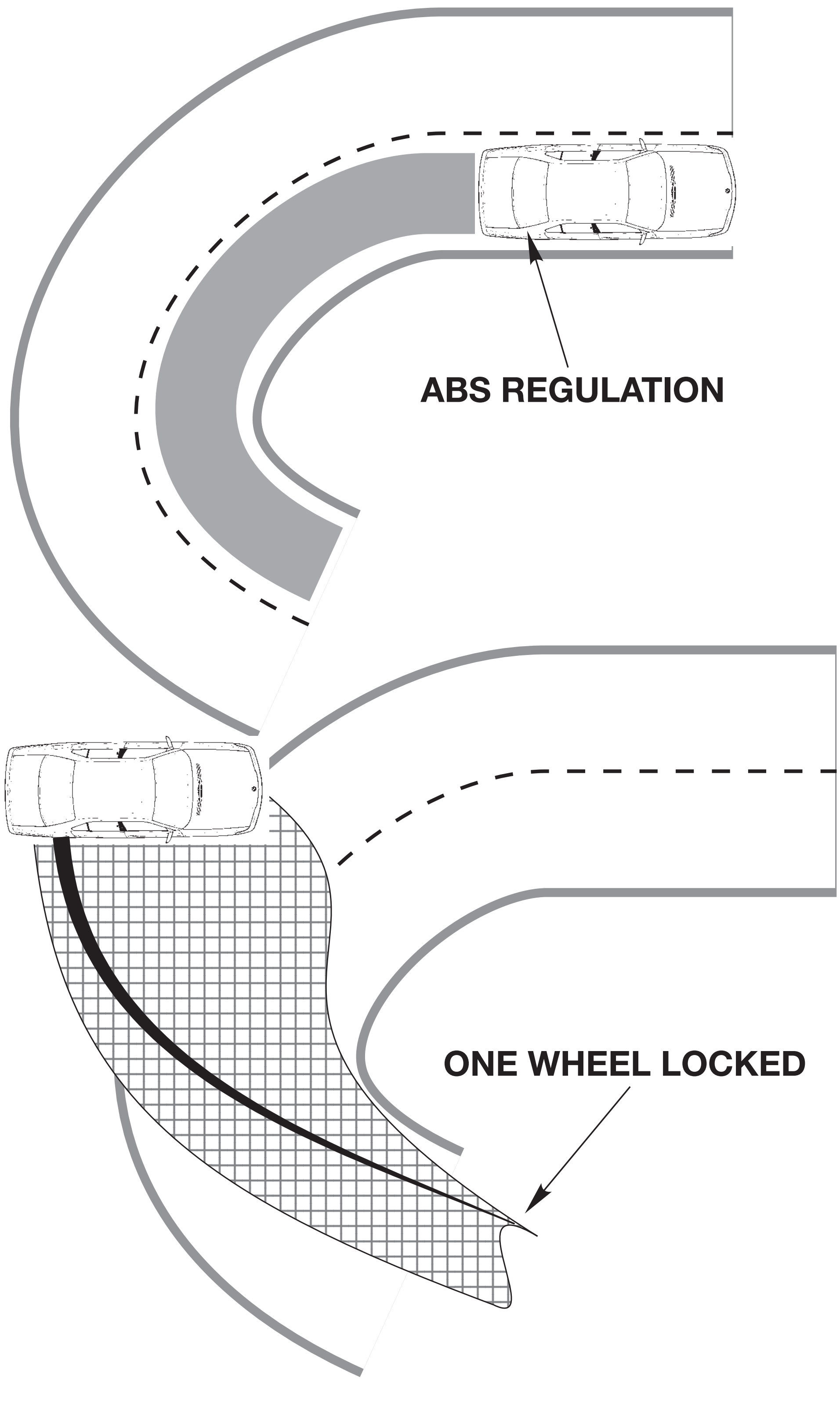
- The electronic control module
- The wheel speed sensors
- The brake hydraulic unit
- The brake master cylinder

The four wheel speed sensors are used as inputs to the control module. The module uses these signals to determine wheel speed, wheel acceleration and deceleration. ABS controlled braking starts when the module detects that one or more wheels are about to lock.

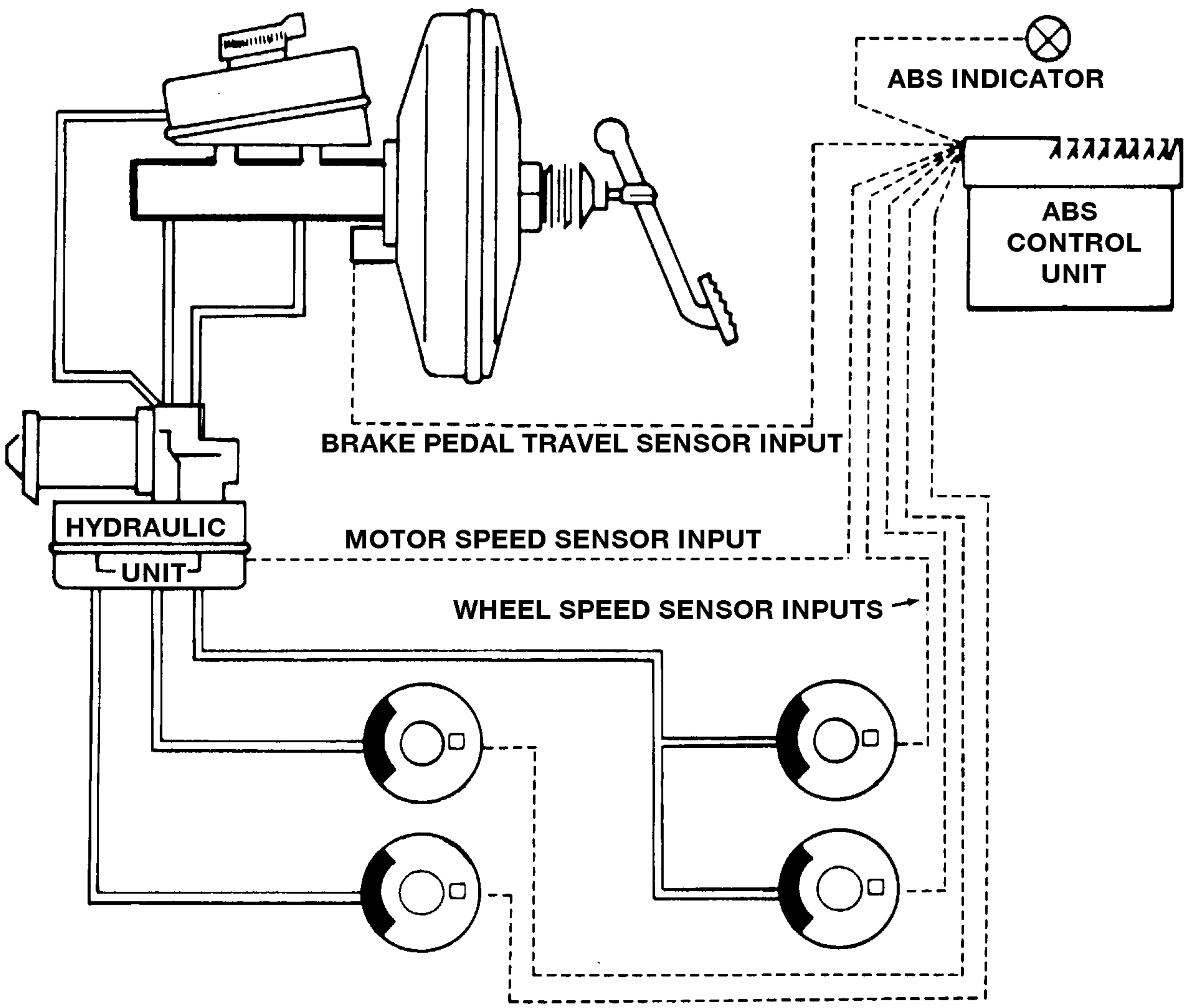
Once activated, the ABS control module pulses the brakes on the affected wheel rapidly (2-15 times a second). This allows the vehicle to be slowed down while still maintaining steerability and directional stability.

The ABS pulses the brakes through solenoids mounted in the hydraulic unit. The solenoids regulate the pressure to the affected wheel through three phases of control:

- Pressure Hold
- Pressure Drop
- Pressure Build


ABS REGULATION
ONE WHEEL LOCKED

Bosch ABS Overview

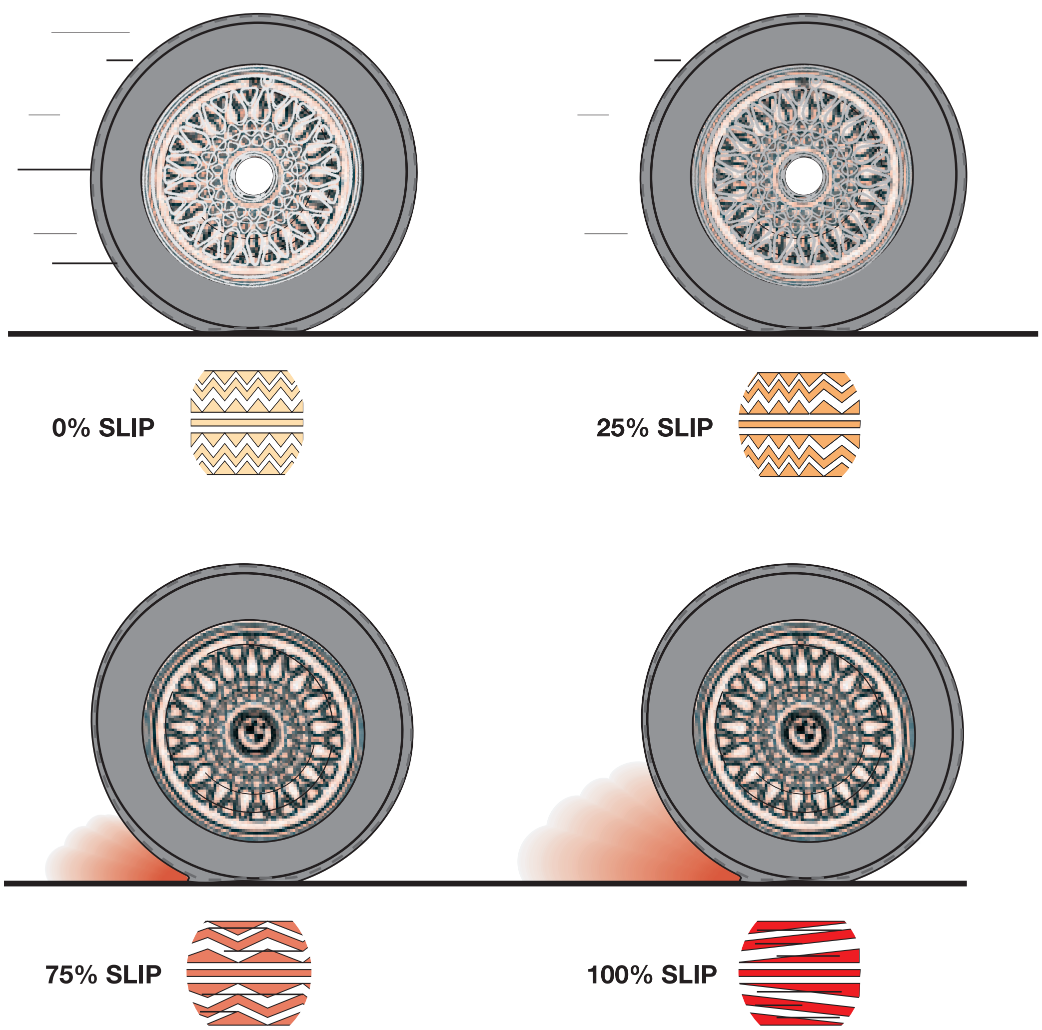


Braking Forces

When the brakes are applied, brake force counters the inertia of the moving vehicle. This force is created by the brake pads acting on the rotors and through the wheel and tire to the roadway. Even in the best of conditions, some wheel slip occurs. Up to a point this wheel slip is acceptable and in most cases it can even be helpful.

When braking, the transmitted brake force concentrates at the tire “foot print”, where the rubber meets the road. This causes a distortion which, when excessive, promotes wheel slip.

When controlled, the distortion can actually enhance the transmission of brake force. Therefore, the ABS logic allows wheel slip up to 20-25%. Beyond that the ABS system limits the application of additional brake force. This allows the transmission of maximum brake force while reducing the stopping distance.



Braking Forces (continued)

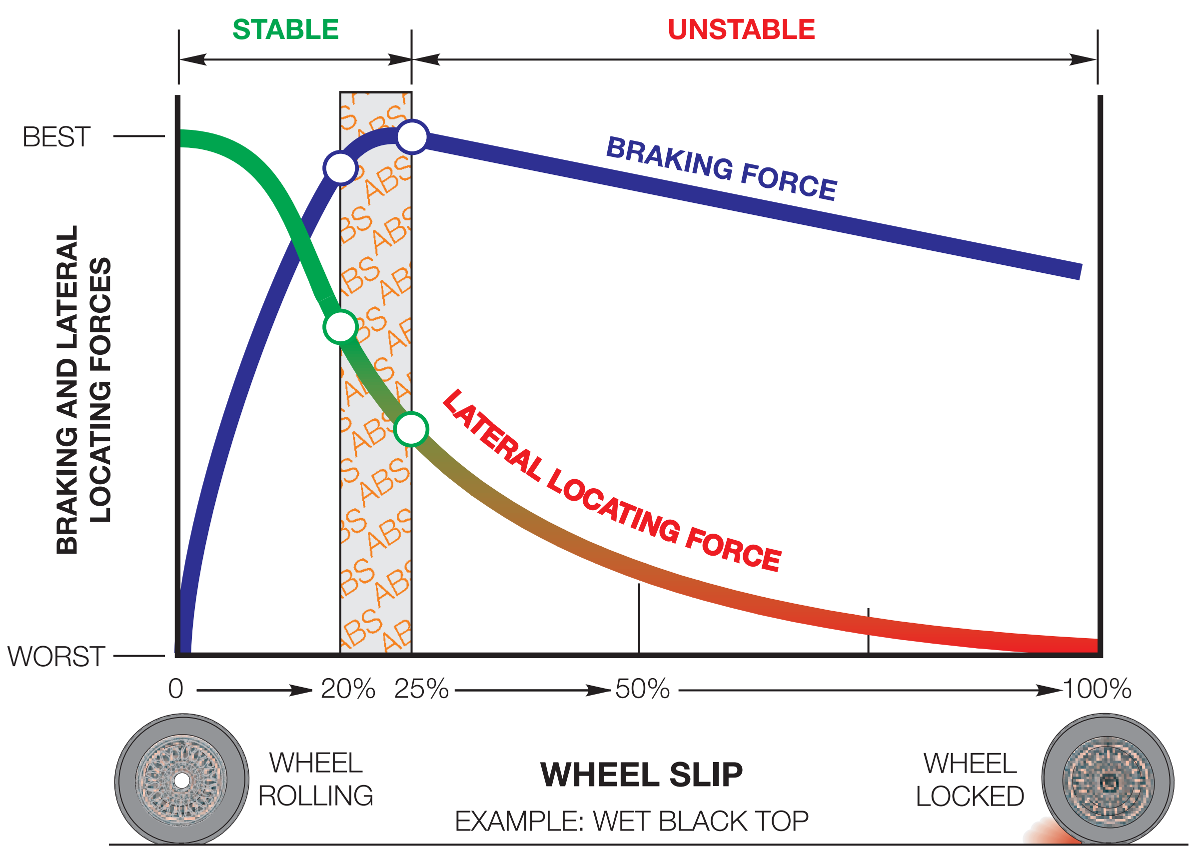
The transmission of braking forces and the retention of Lateral Locating Forces are inverse. That is to say as braking forces increase the locating forces decrease.

As indicated in the chart, the rolling wheel has a wheel slip value of 0% which provides the best Lateral Locating Forces.

As the applied brake force increases the locating force decreases. Depending on the prevailing road surface friction, the optimum transmission of brake force is at the end of the "stable range" with a wheel slip value of 20-25%.

Additional brake force at this point is clearly counter-productive as the additional brake force only increases wheel slip and reduces Lateral Locating Forces.

Therefore the ABS system limits wheel slip by regulating the application of brake force while providing the shortest possible stopping distance.



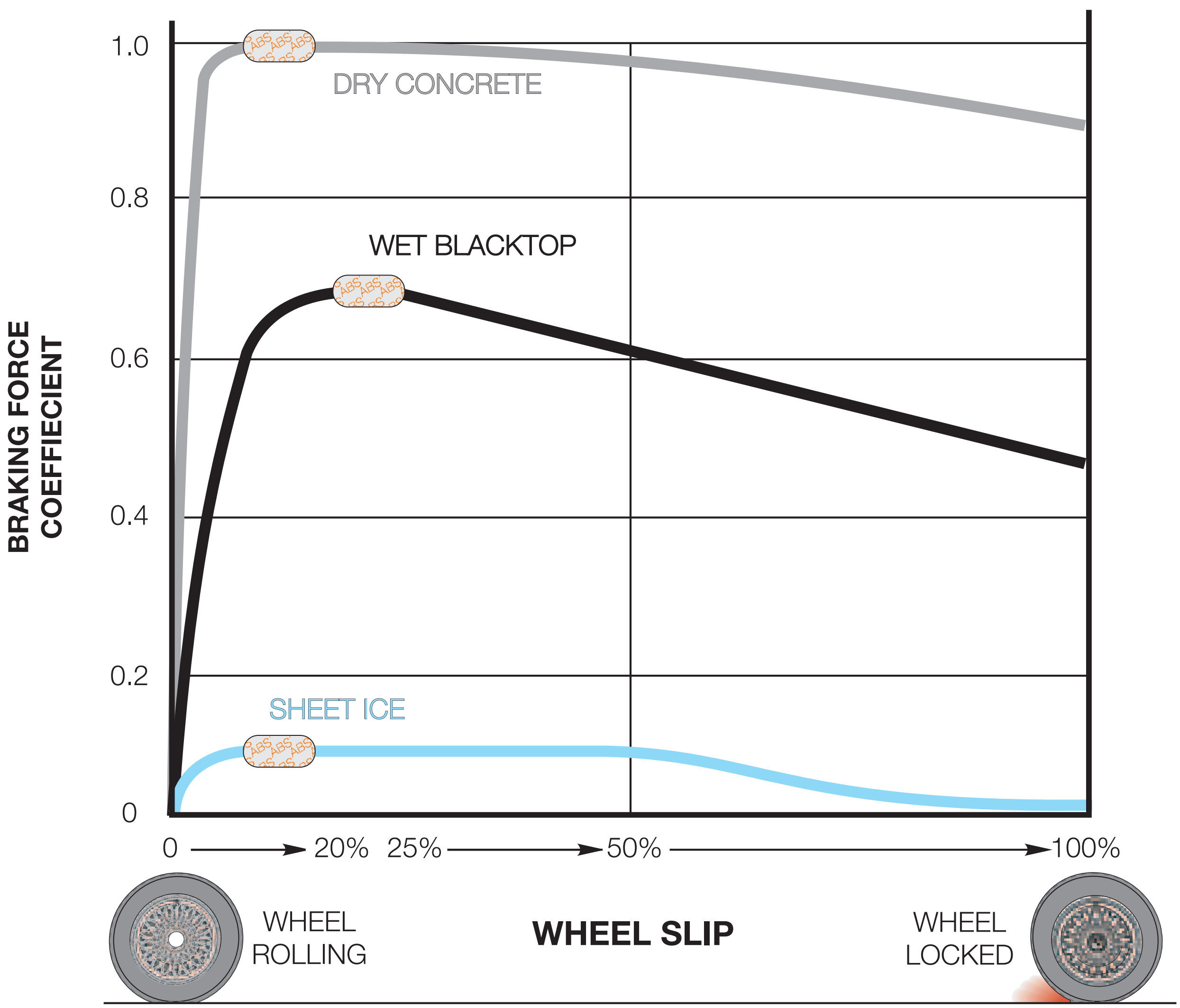
Road Surface

Clearly the condition of the roadway and weather conditions are significant influences regarding wheel slip and the retention of Lateral Locating Forces.

As road surfaces vary and weather conditions impact the tire's ability to maintain good rolling contact, the function of the ABS remains unchanged. Only the stopping distances increase due to the regulated transmission of braking force.

Whatever the road surface or weather, the wheel slip will still be limited to 20-25%.

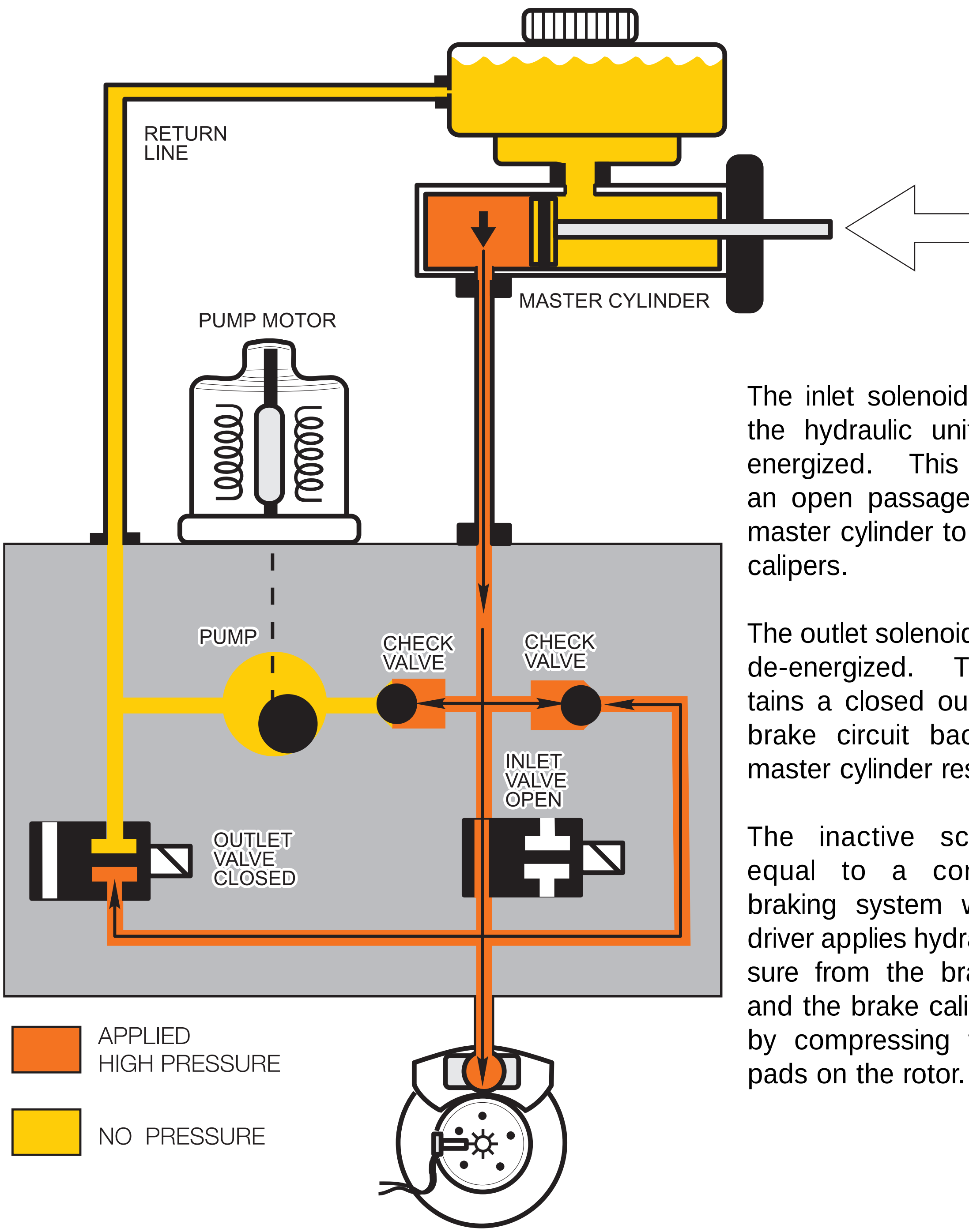
Regardless of the ABS system, good judgement and common sense are still required.



ABS Operation

Normal Braking - "Pressure Build"

The ABS control module constantly monitors and compares the wheel speed sensor signals. When all four signals are at the same frequency within a small window of tolerance, the ABS system is not active and normal braking takes place.



The inlet solenoid valves of the hydraulic unit are de-energized. This maintains an open passage from the master cylinder to the brake calipers.

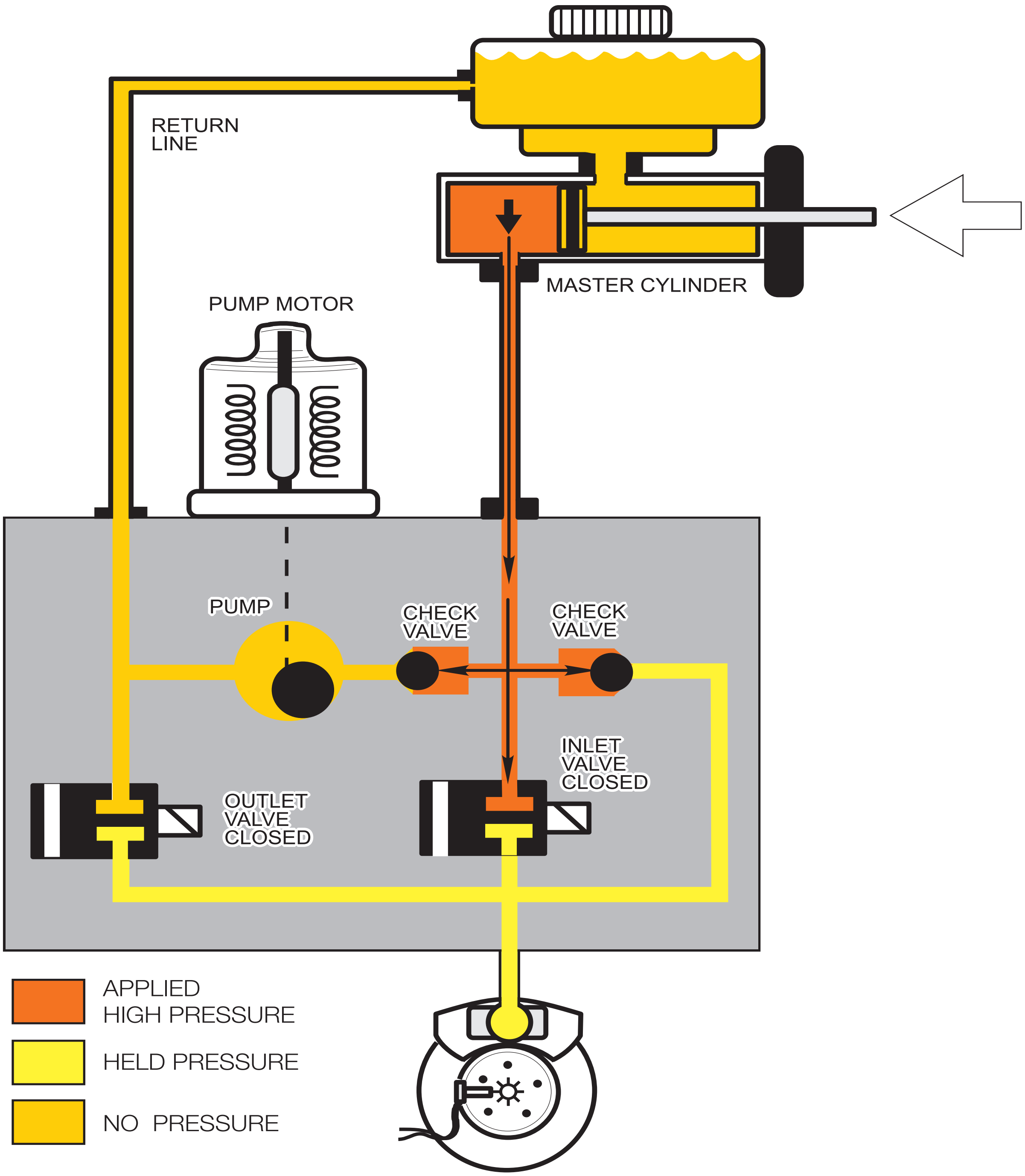
The outlet solenoids are also de-energized. This maintains a closed outlet of the brake circuit back to the master cylinder reservoir.

The inactive scenario is equal to a conventional braking system where the driver applies hydraulic pressure from the brake pedal and the brake calipers react by compressing the brake pads on the rotor.

Pressure Hold

If the control module detects a decrease in the frequency (rate of deceleration) of one or more of the individual signals it perceives this as possible wheel lock.

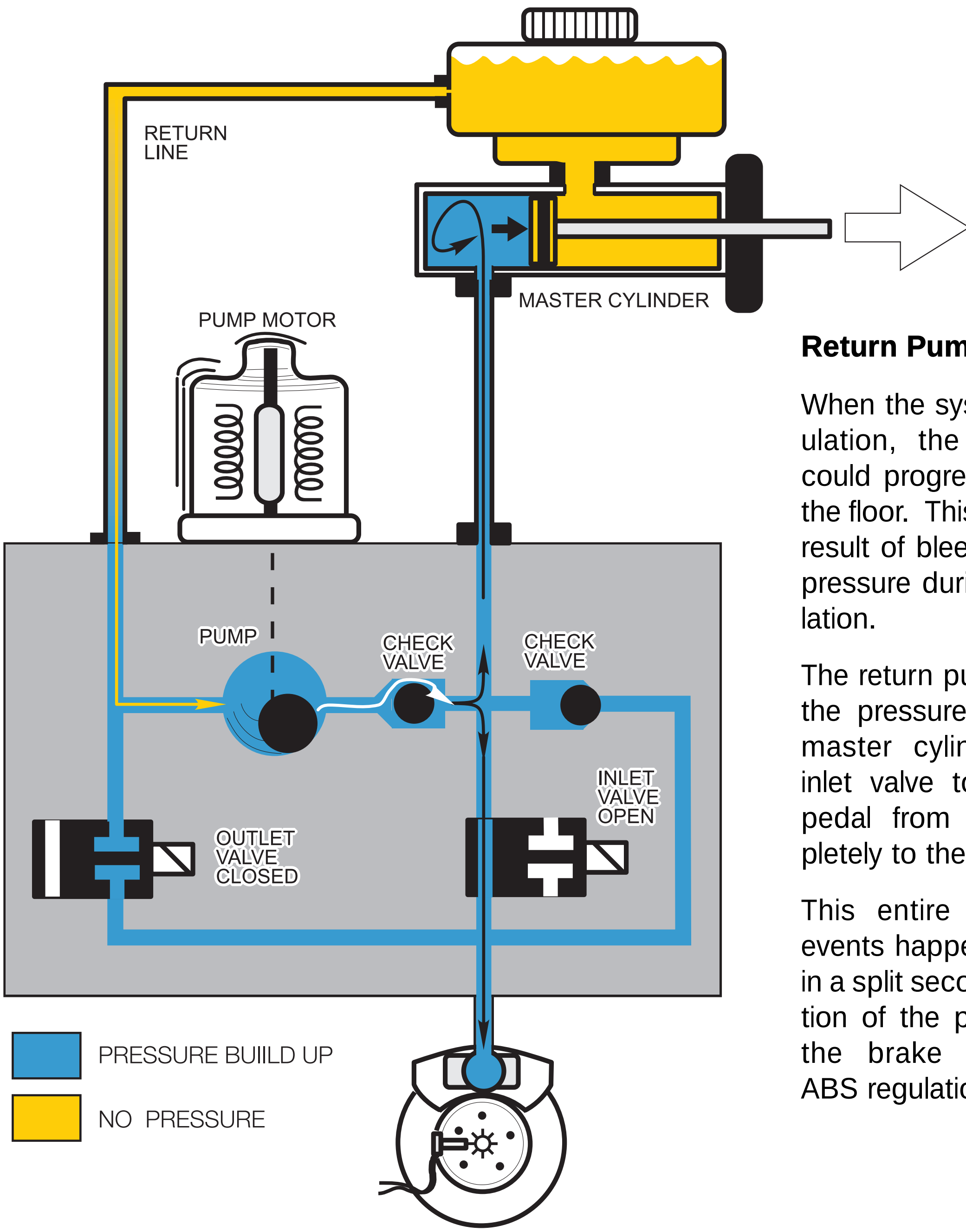
The control module energizes the inlet valve for that specific brake circuit. This closes the inlet port and prevents any additional hydraulic pressure from being exerted on the brake caliper by the driver.



Pressure Drop

The control module de-energizes the inlet and outlet valves. This returns the brake circuit back to normal braking and the hydraulic pressure is once again determined by the driver's pedal force.

This sequence continues rapidly until the wheel speed signals are once again acceptable and the contact of the road and the tire surfaces are restored.



Return Pump Activation

When the system is in regulation, the brake pedal could progressively sink to the floor. This would be the result of bleeding hydraulic pressure during ABS regulation.

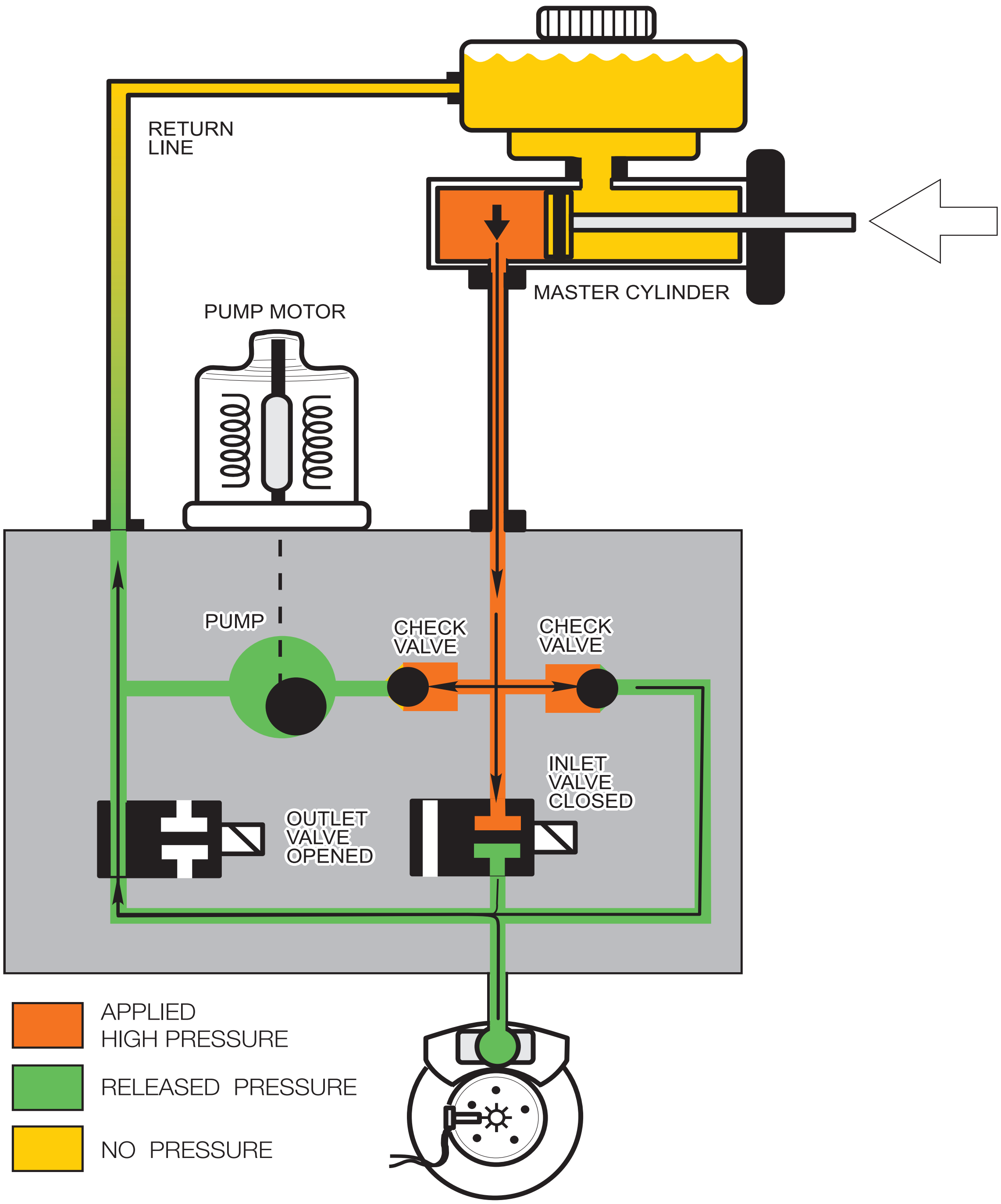
The return pump maintains the pressure between the master cylinder and the inlet valve to prevent the pedal from sinking completely to the floor.

This entire sequence of events happens repeatedly in a split second. The function of the pump is felt in the brake pedal during ABS regulation.

Pressure Drop

With the inlet valve closed the pressure on the caliper is stabilized and isolated. The control module energizes the outlet valve which opens the outlet port and drops the pressure in the isolated portion of the circuit.

The brake fluid flows back to the master cylinder reservoir.



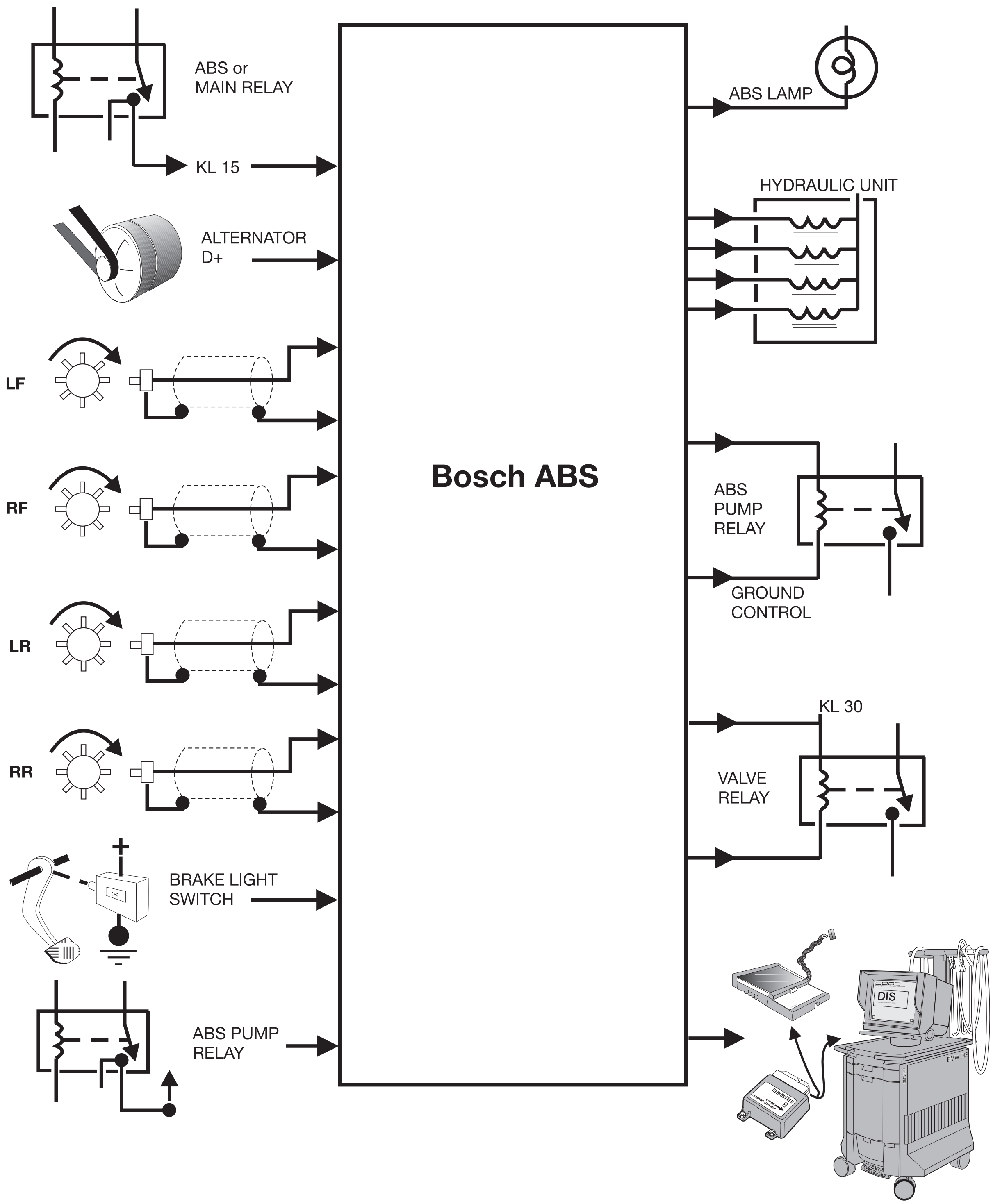
Overview of ABS Systems

BMW uses two basic ABS systems, one manufactured by Bosch and the other by Teves. As of 1991 Model Year - the ABS systems are connected to the diagnostic link* for troubleshooting purposes.

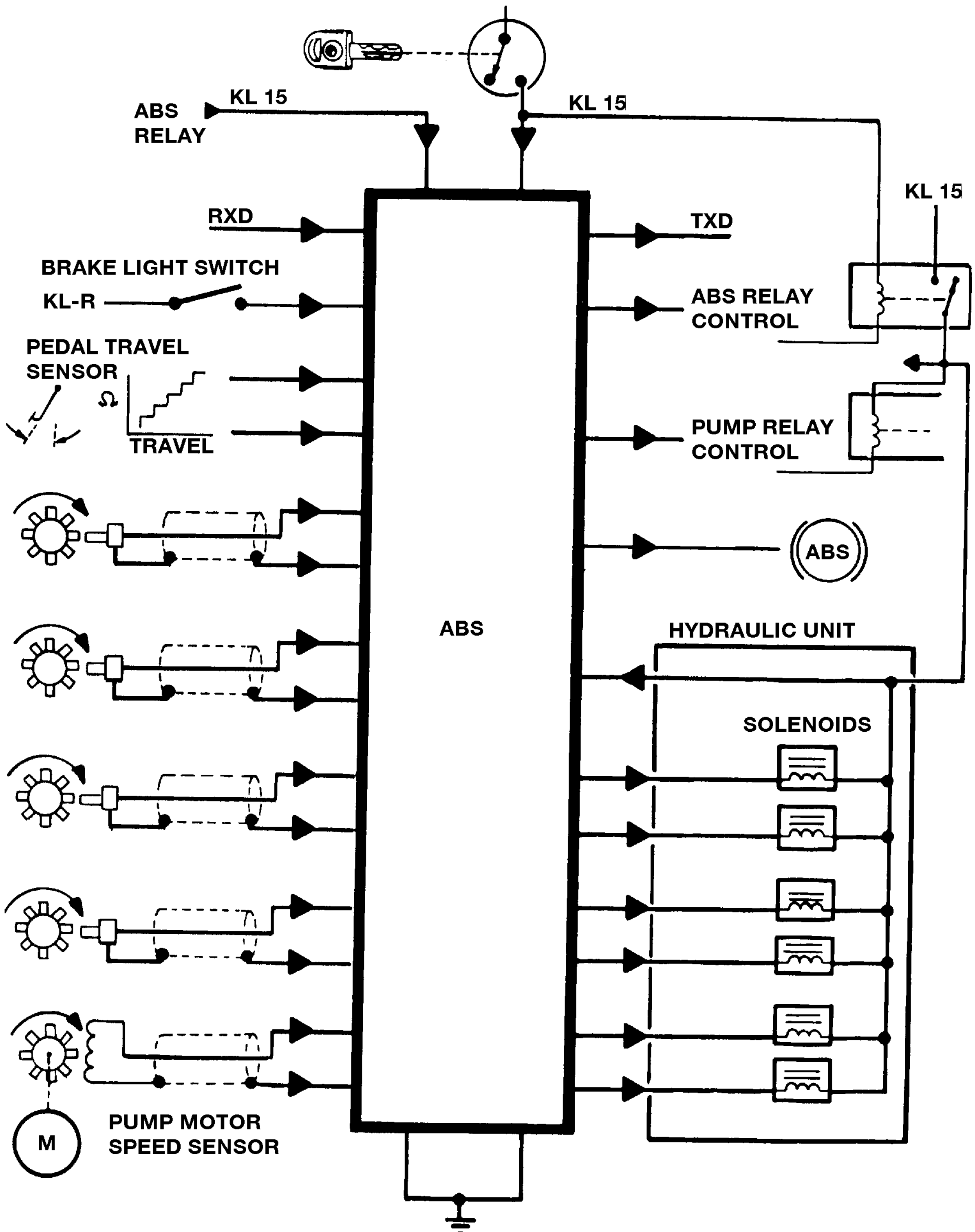
Bosch	**E32** **E34**	**1988-1994*** **1989-1994***
Bosch ABS 5	**E32** **E32**	**1994** **1995**
Teves Mark IV - Open	**E36**	**1992-1994**
Teves Mark IV G (Closed)	**E36** **Z3**	**1995-1996**
Teves Mark 20 I	**E36 318** **Z3**	**1997 (limited production)**

As of 1997 Model Year - Traction Control became standard equipment on all models, with the noted exception of the Mark 20 I ABS system. This system was equipped on a limited number of early production 1997 model year E36 - 318i and Z3 1.9 vehicles produced at Plant 10 in Spartanburg, SC.

Bosch ABS (Typical)



Teves ABS



ABS
RELAY
KL 15
KL 15
KL 15
RXD
TXD
BRAKE LIGHT SWITCH
KL-R
ABS RELAY
CONTROL
PEDAL TRAVEL
SENSOR
Ω
TRAVEL
PUMP RELAY
CONTROL
ABS
ABS
HYDRAULIC UNIT
SOLENOIDS
M
PUMP MOTOR
SPEED SENSOR